

Guard Codes For S-CDMA Systems

5 This application claims priority under 35 USC § 119(e)(1) of Provisional Application
Serial Number 60/115,514, filed January 11, 1999.

TECHNICAL FIELD OF THE INVENTION

10 The present invention relates to a common Synchronous-CDMA (S-CDMA) system.

BACKGROUND OF THE INVENTION

15 In S-CDMA systems a high level of synchronization between transmitting sources is
required, in order to avoid interference between different codes. This requirement imposes high
cost and risk to S-CDMA systems.

SUMMARY OF THE INVENTION

The present invention provides a method for relaxing the timing accuracy requirements in Synchronous Code Division Multiple Access (S-CDMA) systems. The relaxation is done by keeping some of the spreading codes as "guard codes", i.e., not using some of the codes. In this way, interference due to timing error may be decreased. This invention allows for a relaxation of the synchronization requirements at the cost of small decrease in the data throughput of the system, thus decreasing the cost and risk of S-CDMA systems.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention, and the advantages thereof, reference is now made to the following detailed description taken in conjunction with the accompanying drawings, in which:

A common Synchronous-CDMA (S-CDMA) system is shown in Figure 1.

DETAILED DESCRIPTION

A common Synchronous-CDMA (S-CDMA) system is shown in Figure 1. In this system N data symbols are transmitted at the same time from up to N different synchronized sources (each source can transmit one or more data symbols at a given time). Each of these symbols is multiplied by a different spreading code (consisting of N bits). The sequences of the spread symbols are summed (resulting in N “chips”):

$$\underline{p} = \underline{s}^T \cdot \underline{C}$$

where \underline{s} is the vector of the N transmitted symbols, \underline{C} is the matrix of spreading codes (each row in C is a spreading code), and \underline{p} is the sequence of then N transmitted chips.

10 The N spreading codes are orthogonal: $\underline{C} \cdot \underline{C}^T = I$.

In some S-CDMA systems there is one basic code \underline{C}_0 and all the other codes are generated by cyclically shifting the basic code: $C_i[n] = C_0[(n + i) \bmod N]$, $n = 0 \dots N - 1$

The invention is also applicable in cases where the spreading codes are not exactly shifted versions of the basic code, but are highly correlated with the shifted versions. It is also applicable when a few ($n \ll N$) codes are not shifted versions of the basic code at all.

After spreading, the chips are fed into a pulse-shaping filter and transmitted to the channel. In the receiver, the signal is fed into a matched filter and sampled. It is assumed that the convolution of transmitter's shaping filter with the receiver's matched filter is a Nyquist-I filter (e.g. raised-cosine), i.e. there is no inter-symbol interference between the chips (when the sources are synchronized). If we assume that all the transmitting sources are perfectly synchronized, (i.e. the symbol timing at the receiver is identical for all the sources), then the sequence at the matched filter output is \underline{p} (plus channel noise). Multiplying the matched filter output by the transpose of the spreading matrix would recover the transmitted symbols. This operation is called despreading:

$$\hat{\underline{s}} = (\underline{p} + \underline{n}) \cdot \underline{C}^T = \underline{s} \cdot \underline{C} \cdot \underline{C}^T + \tilde{\underline{n}} = \underline{s} + \tilde{\underline{n}}$$

25 However, this behavior is achieved only when the transmitting sources are fully synchronized. In real (non-ideal) systems, full synchronization cannot be achieved. In this case there will be some degree of interference between symbols that are transmitted from different

